Original Research Article

<https://doi.org/10.20546/ijcmas.2018.703.241>

Effect of Phosphorus, Zinc and Iron on Yield and Quality of Wheat in Western Rajasthan, India

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ABSTRACT

Keywords

Phosphorus, Zinc, Iron, Yield, Chlorophyll content, Protein content, Wheat

Article Info

Accepted:
16 February 2018
Available Online:
10 March 2018

A field experiment was carried out during two consecutive *rabi* seasons of 2009-10 and 2010-11 at the Agronomy farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner to find out the effect of phosphorus, zinc and iron on yield and quality of wheat (*Triticum aestivum* L.) in Loamy sand soils of Western Rajasthan with ten treatments comprising 4 levels of phosphorus (0, 20, 40 and 60 kg ha⁻¹) and zinc (0, 3 and 6 kg ha⁻¹) in main plots and 3 levels of iron (0, 3 and 6 kg ha⁻¹) in split-plot design with three replications. Application of phosphorus up to 40 kg P₂O₅ ha⁻¹ significantly increased the grain, straw and biological yields beyond which it increased non-significantly and registered a mean increase of 26.2, 30.6 and 28.8 per cent, respectively over control. Application of phosphorus @ 40 kg P₂O₅ ha⁻¹, 3 kg Zn ha⁻¹ and of 6 kg Fe ha⁻¹ significantly increased the chlorophyll content of wheat at flowering stage and protein content of grains in wheat during both the years of investigations and in pooled analysis. Whereas, Application of higher doses of phosphorus, zinc and iron did not had significant effect on total sugar content of grain and crude fibre content.

Introduction

Wheat [*Triticum aestivum* (L.)] is the second most important food grain crop in India ranking next to rice (*Oryza sativa* L.) contributing about 35% of the food grain production in India. India occupies second position next to China in the World with regard to area 30.96 million hectares and production 88.94 million tones with average productivity of 28.72 q ha⁻¹ of wheat

(Anonymous, 2014-15). In India, main wheat growing states are UP, Punjab, Haryana, M.P., Rajasthan and Bihar. In Rajasthan, wheat has an area of 2.94 million hectares with the production of 9.86 million tonnes. The average productivity of wheat in the state is 33.65 q ha⁻¹ (Anonymous, 2014-15). This clearly indicates that in spite of considerable improvement in genetic potential of the crop, productivity is still very poor in the country as well as in the state of Rajasthan. The high

productivity of wheat can only be achieved by the adoption of suitable variety and improved agronomic practices with balanced and judicious use of chemical fertilizers in an integrated way.

Among the essential nutrients, phosphorus occupies a key place in intensive agriculture and is considered as a backbone of any fertilizer management programme. Application of phosphorus not only increases the crop yield but also improves crop quality and imparts resistance against diseases. It is involved in wide range of plant processes as permitting cell division, development of sound root system and ensuring timely and uniform ripening of crop. It participates in metabolic activities as a constituent of nucleoprotein and nucleotides and also plays a key role in the formation of energy rich bond phosphate like Adenosine diphosphate and Adenosine triphosphate. It plays a vital role in virtually every plant process like photosynthesis, energy storage and transfer, stimulating root development and growth, giving plant rapid and vigorous start leading to better tillering in wheat, encouraging earlier maturity and seed formation. Therefore, sufficient quantity of soluble form of phosphorus fertilizers is applied to achieve maximum plant productivity. However, the applied soluble forms of phosphatic fertilizers rapidly become unavailable to plants by conversion into inorganic P fractions that are fixed by chemical adsorption and precipitation. Similarly, organic P fractions are immobilized in soil organic matter (Sanyal and De Dutta, 1991).

Micronutrients were first recognized as a limiting factor in crop production in United States in Florida during the 1920's. Micronutrients play a vital role in enhancing crop productivity. Intensification of agriculture with high yielding varieties, continuous use of high analysis fertilizers,

restricted supply of organic manures and negligible crop residue return to soil led to micronutrient deficiency. The overall deficiency of micronutrient in Indian soil was found to be 47 per cent for Zn, 2 per cent for Cu, 13 per cent for Fe and 4 per cent for Mn (Sakal and Singh, 2001). The present investigation was carried out to evaluate and describe the fertilizer phosphorus, zinc and iron application on growth attributes and yield attributes of wheat in Loamy sand soils of Western Rajasthan.

Materials and Methods

The experiment was conducted at the Agronomy farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *rabi* seasons of 2009-10 and 2010-11. The experimental site is located at 28.01°N latitude and 73.22°E longitude at an altitude of 234.7m above mean sea level and falls under Agro-ecological region No. 2 (M9E1) under Arid ecosystem (Hot Arid Eco-region), which is characterized by deep, sandy and coarse loamy, desert soils with low water holding capacity and hot and arid climate.

The soils of experimental field was loamy sand in texture having pH -8.2, EC -0.22 dS m⁻¹, available N – 90.1 kg ha⁻¹, available P₂O₅ – 14.2 kg ha⁻¹, available K₂O – 160.4 kg ha⁻¹, available Zinc- 0.34 mg kg⁻¹, available iron- 2.90 mg kg⁻¹ and organic carbon-0.15%.

The field experiment on wheat in *rabi* seasons of 2009-10 and 2010-11 was laid out comprising 4 levels of phosphorus (0, 20, 40 and 60 kg ha⁻¹) and zinc (0, 3 and 6 kg ha⁻¹) in main plots and 3 levels of iron (0, 3 and 6 kg ha⁻¹) in sub plots. A total of 36 treatment combinations were tested in split plot design with three replications. The treatment details are follows:

(A) Main plot treatments

Phosphorus levels

P_0 = Control, P_1 = 20 Kg ha⁻¹, P_2 = 40 Kg ha⁻¹ and P_3 = 60 Kg ha⁻¹

Zinc levels

Zn_0 = Control, Zn_1 = 3 Kg ha⁻¹ and Zn_2 = 6 Kg ha⁻¹

(B) Sub plot treatments

Iron levels

Fe_0 = Control, Fe_1 = 3 Kg ha⁻¹ and Fe_2 = 6 Kg ha⁻¹

Nitrogen was applied @ 120 kg N ha⁻¹ was applied RDF. Half dose was applied as basal through urea after adjusting the quantity of N supplied by DAP. Remaining half dose of N was applied through broadcasting of urea in two equal split doses just after irrigation at 25 and 75 DAS. Potassium was applied @ 20 kg K₂O ha⁻¹ was applied through muriate of potash before sowing. Phosphorus: Phosphorus was applied through DAP, zinc was applied through zinc sulphate and iron was applied through ferrous sulphate before sowing as per treatment. Seeds were treated with thiram (2 g kg⁻¹ seed) as prophylactic measures against seed borne diseases. The wheat variety 'Raj-3077' was sown by "kera" method at a depth of 5 cm in rows spaced at 22.5 cm apart on 25th and 28th November in the years 2009-10 and 2010-11, respectively using seed rate of 120 kg ha⁻¹.

The grain yield of each net plot was recorded in kg plot⁻¹ after cleaning the threshed produce and was converted as kg ha⁻¹. Straw yield was obtained by subtracting the grain yield (kg ha⁻¹) from biological yield (kg ha⁻¹). The harvest index was calculated by using

following formula and expressed as percentage (Singh and Stoskoof, 1971).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Fresh leaves collected at flowering stage from each plot were washed twice with water and once with distilled water. Treatment wise fresh leaf sample of 0.1 g was taken and ground in 80 per cent acetone, filtered from filter paper No. 42 and volume was made upto 25 ml. The resultant intensity of colour was measured in UV-VIS spectrophotometer 118 (systronics) at specific wave length (645 mμ and 663 mμ) to estimate chlorophyll 'a' and chlorophyll 'b' content (Arnon, 1949).

Chlorophyll 'a' content (mg g⁻¹) =

$$\frac{12.7 A_{663} - 2.69 A_{645}}{a \times 1000 \times w} \times V$$

Chlorophyll 'b' content (mg g⁻¹) =

$$\frac{22.9 A_{645} - 4.68 A_{663}}{a \times 1000 \times w} \times V$$

Where,

a = Length of light path in cell (usually 1 cm)

w = Fresh weight of leaf samples (g)

v = Volume of extract (ml)

Total chlorophyll content (mg g⁻¹) = Chlorophyll 'a' + Chlorophyll 'b'

The protein content in grain was calculated by multiplying per cent nitrogen content with a factor of 6.25 (A.O.A.C., 1970). The sugar content was determined by the method described by AOAC (1970). The crude fiber content was calculated by using following formula and expressed in percentage as described by AOAC (1970).

Crude fiber (%) =

$$\frac{\text{Weight of residue} - \text{Weight of ash}}{\text{Amount of substance taken}} \times 100$$

Results and Discussion

Effect of phosphorus

Application of phosphorus at 40 kg P₂O₅ ha⁻¹ significantly increased the grain yield, straw yield and biological yield over control during both year of experimentation and pooled analysis (Table 1). The significant increase in grain yield of wheat due to application of phosphorus up to 40 kg P₂O₅ ha⁻¹ was largely a function of improved growth and the consequent increase in different yield attributes. The grain yield of wheat increased by 762 kg ha⁻¹ due to application of 40 kg P₂O₅ ha⁻¹ over control. Jain and Dahama (2006) and Jat *et al.*, (2007) also recorded significant improvement in wheat grain yield with increase in phosphorus levels. The significant increase in straw yield due to application of phosphorus could be attributed to the increased vegetative growth as evident from dry matter production and CGR possibly as a result of the effective uptake and utilization of nutrients absorbed through its extensive root system developed under phosphorus fertilization (Rathi and Singh, 1976).

The biological yield is a function of grain and straw yields. Thus, significant increase in biological yield with the application of phosphorus could be ascribed to the increased grain and straw yields. The faster rate of improvement in grain yield as compared to straw yield to phosphorus fertilization led to significant improvement in biological yield thereby suggesting better source and sink relationship. These results are in conformity with those of Jat *et al.*, (2007) and Sepat and Rai (2013).

Data perusal in Table 2 revealed that application of phosphorus @ 40 kg P₂O₅ ha⁻¹ significantly increased the chlorophyll content of wheat at flowering stage during both the years of investigations and in pooled analysis. This may be attributed to increased N content in grain and its uptake by the crop and role of P in energy conservation and transformation. Higher nitrogen content in grain due to P fertilization resulted in higher crude protein content as nitrogen is an integral part of protein. Such increase in protein content is due to the reduction of nitrates to ammonia by the activities of complex enzymes resulting in production of more amino acids, which are main constituents of protein. These results are corroborates with the findings of Azad *et al.*, (2010) and Pingoliya *et al.*, (2015).

Effect of zinc

Application of zinc at 3 kg ha⁻¹ significantly increased the number of yield of wheat over control during both the years (Table 1). The increase in the yield due to zinc application may be attributed to the fact that the initial status of available zinc in the experimental soil was low. The increase in yield attributes may be due to increased supply of available zinc to plants by way of its addition to soil which resulted in proper growth and development. The increase in the yield attributes might be due to role of zinc in biosynthesis of indole acetic acid (IAA) and especially due to its role in initiation of primordia for reproductive parts and partitioning of photosynthates towards them, which resulted in better flowering and fruiting. The significant increase in straw yield due to zinc fertilization could be attributed to the increased plant growth and biomass production, possibly as a result of the uptake of nutrients. Similar results were reported by Singh *et al.*, (2015) and Arshad *et al.*, (2016).

Table.1 Effect of phosphorus, zinc and iron on yield (kg ha⁻¹) and harvest index of wheat

Treatments	Grain yield kg ha ⁻¹			Straw yield kg ha ⁻¹			Biological yield kg ha ⁻¹			Harvest index		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
Phosphorus levels (P₂O₅ Kg ha⁻¹)												
Control	2815	2986	2901	4176	4208	4192	6990	7195	7093	39.23	40.79	40.01
20	3329	3503	3416	4854	5097	4975	8184	8600	8392	40.80	41.24	41.02
40	3584	3743	3663	5396	5557	5476	8980	9300	9140	39.94	40.24	40.09
60	3644	3826	3735	5544	5641	5593	9195	9467	9331	39.81	40.39	40.10
SEm±	51	50	36	72	66	49	121	105	80	0.92	0.59	0.55
CD (P=0.05)	149	146	101	210	193	138	354	307	228	NS	NS	NS
Zinc levels (Zn Kg ha⁻¹)												
Control	3049	3205	3127	4636	4829	4733	7685	8034	7860	38.94	39.48	39.21
3	3453	3625	3539	5105	5235	5170	8557	8860	8709	40.43	41.12	40.77
6	3527	3714	3620	5236	5313	5275	8769	9027	8898	40.47	41.40	40.93
SEm±	44	43	31	62	57	42	105	91	69	0.80	0.51	0.47
CD (P=0.05)	129	127	88	182	167	120	307	266	197	NS	NS	NS
Iron levels (Fe Kg ha⁻¹)												
Control	3032	3187	3109	4560	4756	4658	7597	7944	7771	39.27	39.66	39.47
3	3451	3624	3538	5136	5267	5202	8588	8891	8739	40.27	40.94	40.60
6	3546	3733	3640	5281	5354	5317	8827	9087	8957	40.30	41.39	40.85
SEm±	52	55	38	59	61	43	117	105	78	0.82	0.60	0.51
CD (P=0.05)	149	158	107	169	173	119	332	298	220	NS	NS	NS

Table.2 Effect of phosphorus, zinc and iron on quality parameters of wheat

Treatments	Chlorophyll content (mg g ⁻¹ of fresh leaves)			Protein content of grain (%)			Total sugar content of grain (%)			Crude fiber content of grain (%)		
	2009- 10	2010- 11	Poole d	2009-10	2010-11	Poole d	2009-10	2010- 11	Poole d	2009-10	2010-11	Pooled
Phosphorus levels (P₂O₅ Kg ha⁻¹)												
Control	2.17	2.22	2.19	8.91	8.74	8.83	10.92	10.67	10.79	32.17	32.00	32.08
20	2.61	2.66	2.64	9.67	9.82	9.74	10.94	11.05	11.00	31.60	31.66	31.63
40	2.78	2.85	2.82	10.17	10.07	10.12	11.03	11.07	11.05	31.26	31.18	31.22
60	2.87	2.92	2.90	10.29	10.28	10.29	11.07	11.31	11.19	31.17	30.71	30.94
SEm±	0.06	0.05	0.04	0.10	0.14	0.09	0.30	0.21	0.18	0.40	0.45	0.30
CD (P=0.05)	0.18	0.14	0.11	0.28	0.42	0.25	NS	NS	NS	NS	NS	NS
Zinc levels (Zn Kg ha⁻¹)												
Control	2.29	2.34	2.31	9.40	9.38	9.39	10.94	10.86	10.90	31.71	31.52	31.61
3	2.72	2.79	2.76	9.87	9.83	9.85	10.97	11.06	11.01	31.63	31.46	31.54
6	2.81	2.86	2.84	10.01	9.98	9.99	11.07	11.16	11.11	31.32	31.18	31.25
SEm±	0.05	0.04	0.03	0.08	0.12	0.08	0.26	0.19	0.16	0.34	0.39	0.26
CD (P=0.05)	0.16	0.12	0.10	0.25	0.37	0.21	NS	NS	NS	NS	NS	NS
Iron levels (Fe Kg ha⁻¹)												
Control	2.31	2.37	2.34	9.42	9.40	9.41	10.77	10.74	10.75	31.63	31.44	31.53
3	2.68	2.74	2.71	9.87	9.75	9.81	11.06	11.16	11.11	31.54	31.36	31.45
6	2.84	2.89	2.86	9.99	10.04	10.01	11.15	11.19	11.17	31.49	31.36	31.42
SEm±	0.04	0.03	0.02	0.12	0.13	0.09	0.22	0.15	0.13	0.28	0.28	0.20
CD (P=0.05)	0.11	0.09	0.07	0.35	0.36	0.25	NS	NS	NS	NS	NS	NS

Application of zinc @ 3 kg ha⁻¹ significantly increased the chlorophyll content of wheat at flowering stage during both the years of study as well as on pooled basis. Experimental results also showed a significant increase in protein content in grain of wheat due to the application of zinc up to 3 kg ha⁻¹. Application of zinc in soil increased the availability of zinc in the rhizosphere. The role of zinc in increasing the metabolic and physiological activity of the plants is of great significance as it influences the activities of hydrogenase and carbonic anhydrase, stabilization of ribosomal fractions and synthesis of cytochrome (Tisdale *et al.*, 1984). Similar results were also been reported by Shivay *et al.*, (2014) and Paramesh *et al.*, (2014).

Effect of iron

Application of 3 kg Fe ha⁻¹ significantly increased the grain yield (Table 1) over control but it was found statistically at par with 3 kg Fe ha⁻¹. An increase in grain yield may be attributed to the significant increase in number of effective tiller per plant and number of grains per ear. Further, increase in grain yield due to iron application in the soil could possibly be due to the enhanced metabolites of carbohydrates and protein and their transport to the site of grain production. Since iron is a constituent of ferredoxin and cytochromes, which involved in photosynthesis, the increase in iron supply could result in enhanced synthesis of carbohydrates. Similarly, significant increase in straw yield was recorded with the application of 3 kg Fe ha⁻¹. This might be due to increased crop growth and development viz. dry matter accumulation and yield attributes of plants under better nutritional environment, under the application of iron. Significant increase in grain and straw yield due to iron application has also been reported by Habib (2009). The biological yield is a

function of grain and straw yields. Thus, increase in biological yield with the application of iron could be ascribed to increase grain and straw yields. These results are in line conformity of findings of Gill and Walia (2014).

Application of iron @ 6 kg ha⁻¹ significantly increased the chlorophyll content of wheat at flowering stage during both the years of study as well as on pooled basis. Application of Fe @ 6 kg ha⁻¹ significantly increased mean chlorophyll content by 22.20 per cent and 5.77 per cent over control and 3 kg Fe ha⁻¹, respectively. Data perusal in table 2 revealed that application of Fe @ 6 kg ha⁻¹ significantly increased mean chlorophyll content by 22.20 per cent and 5.77 per cent over control and 3 kg Fe ha⁻¹, respectively. Whereas, application of iron @ 3 kg ha⁻¹ increased the protein content of wheat significantly during both the years of experimentation as well as in the pooled analysis. However, total sugar content of grain and crude fiber content of grain did not affected significantly during both the years of study as well as in the pooled analysis. Iron might have helped in greater nitrogen uptake by plant and translocation in various plant parts including grain. Since nitrogen is essential constitute of protein, increased nitrogen content led to higher protein content. These results corroborative with the findings of Pingoliya *et al.*, (2015).

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How to cite this article:

Ram Chandar Jat, Yogesh Sharma, R.K. Jakhar and Sharma, R.K. 2018. Effect of Phosphorus, Zinc and Iron on Yield and Quality of Wheat in Western Rajasthan, India. *Int.J.Curr.Microbiol.App.Sci*. 7(03): 2055-2062. doi: <https://doi.org/10.20546/ijcmas.2018.703.241>